Trauma Surgery & Acute Care Open

Penetrating neck trauma: a comprehensive review

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ABSTRACT

Although the overall incidence is low, penetrating neck trauma can result in devastating injuries. The traditional zonal approach is being increasingly abandoned in favor of selective approaches, especially as mandatory exploration can result in non-therapeutic interventions and associated complications. Additionally, the trajectory of the missile cannot be accurately assessed based on external wounds. Decision-making using the hard and soft signs of trauma and increased resolution of imaging modalities are progressively supplanting the older zonal approaches. Here we discuss the modern diagnostic approach, operative interventions, and the appropriateness of observation.

INTRODUCTION

Epidemiology

Penetrating neck injury (PNI) is best described as an injury caused by a missile that penetrates the platysma muscle from the base of the skull superiorly to the sternum inferiorly. Isolated neck injuries represent up to 10% of all trauma cases, and mortality can be as high as 10%.[1 2] Most commonly, injuries are caused by stab wounds, although gunshot wounds (GSWs) constitute a large plurality of the incidence as well.[3] Majorly injured structures in descending order of incidence include the internal jugular vein, cervical spine, larynx, external jugular, vertebral arteries, pharynx, and vagus nerve.[4] Between 35% and 50% of GSW victims will have clinically significant injuries compared with 10%–20% of stab wound victims.[5 6]

History

Neck trauma has been of interest to trauma surgeons, and data have been collected as early as the American Civil War, where more than 4000 cases of neck wounds were reported with a mortality of greater than 35% without operative intervention.[7] Care of these wounds remained primarily non-operative in nature, well into the 20th century.[6] World War I demonstrated a mortality of greater than 16% with this management, and it was not until World War II that mandatory neck exploration was instituted among allied forces, with a subsequent reduction in mortality to 4%–7%.[8–11] However, as expected, the negative exploration rate was extremely high, and alternative clinical criteria were sought.[11]

The zones of the neck have been classically used to assist in decision-making and were particularly useful in the pre-CT era. Monson *et al* first described these three zones in 1969 at the Cook County Hospital, and this definition was further refined by Roon and Christensen in 1979.[12 13] (table 1)

After the advent of thin-sliced, high-quality CT angiography imaging and improvements in accessibility, management has increasingly shifted to patient-specific surgical management. For example, this approach is beginning to obviate the need for mandatory exploration in certain zone II injuries. This 'no zone' approach, although becoming popular parlance, still requires astute decision-making, and when the provider is in doubt, consultation with experienced trauma or vascular surgeons should be undertaken.

ANATOMY AND CLASSICAL ZONES OF THE NECK

Definition of the neck and divisions

The neck is bounded superiorly by the mandible and inferiorly by the clavicles.[14] There are many important structures running through the neck, making it of critical importance to have a complete evaluation when injury occurs to this area. Anatomically, the neck is divided into the anterior and posterior triangles, which both contain further subdivisions into smaller triangles.[14] The anterior triangle is further divided into the submental, submandibular, carotid, and muscular triangles.[14] The posterior triangle is divided into the occipital triangle and the subclavian triangle.[14] Although these anatomic classifications are important and assist in identifying critical structures, in traumatic injuries, the zone classification systems have been used to aid in management decisions.

There are three traditional zones of the neck (figure 1).[15] Zone I extends from the clavicles and sternal notch to the cricoid cartilage. Zone II is located between the cricoid cartilage and the angle of the mandible.[13 16] Zone III is the most superior zone and extends from the angle of the mandible to the base of the skull.[13 16] These classifications have been used to try and predict what structures are most at risk for injury based on what they contain. Zone I contains the innominate and subclavian vessels, carotid artery origin and vertebral artery, the brachial plexus, esophagus, trachea, and lung apex.[16] Zone II contains the carotid and vertebral arteries, the internal jugular veins, the esophagus, trachea, and cranial nerves X, XI, and XII (online supplemental video 2).[16 17] Zone III contains the distal vertebral and carotid arteries, the pharynx, as well as cranial nerves VII, IX, X, XI, and XII[16 17] (table 1). Operative exposure of the common carotid, internal jugular, and vagus nerve has been demonstrated in figure 2.

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Table 1 Boundaries and contents of traditional neck zones

Zone	Boundaries	Contents
1	Sternal notch to cricoid cartilage	Major vessels of superior mediastinum, innominate and subclavian vessels, internal jugular vein, carotid artery origin and vertebral artery, brachial plexus, vagus nerve, recurrent laryngeal nerve, phrenic nerve, esophagus, trachea, and lung apex
2	Cricoid cartilage to angle of the mandible	Common, internal, and external carotid arteries, vertebral arteries, internal jugular veins, esophagus, trachea, larynx, pharynx, cranial nerves X, XI, and XII, recurrent laryngeal nerve, and phrenic nerve
3	Superior from the angle of the mandible	Distal vertebral and carotid arteries, jugular veins, oropharynx, pharynx, cranial nerves VII, IX, X, XI, and XII

MANAGEMENT

Historically, injuries to the neck were managed based on zone and mechanism of injury. Zone II injuries were all taken for mandatory operative neck exploration whereas zones I and III were managed based on stability and symptoms as they are more difficult to access.[16] We have since evolved this to be more nuanced based on injury location, mechanism, patient stability, and imaging, which we will discuss in depth in the following sections.

Prehospital assessment and management

Prehospital care of PNIs can often be difficult, and emergency medical service (EMS) providers should be properly educated that management cannot be universal. Impaled objects should not be removed.[18] Patients who are adequately protecting their airway, regardless of the subjective extent of damage, should only be cautiously intubated. Patients with significant agitation and hemodynamic instability should be intubated with rapid sequence intubation (RSI), but cricoid pressure and bag valve mask ventilation should be avoided to prevent worsening of aerodigestive tract or great airway injuries.[19 20] RSI was found to be very effective even in the setting of PNI when performed at the discretion of the provider.[20] Although there is no evidence for the use of video laryngoscope (VL) versus direct laryngoscope (DL) intubation in the setting of PNI, VL has been demonstrated to have superior success rates in other prehospital patients and intuitively should be expected to be higher quality

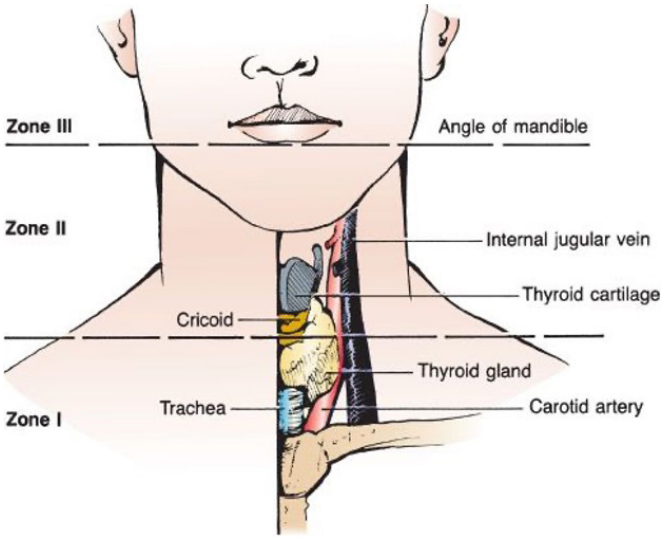

Figure 1 Zones of the neck.[15]

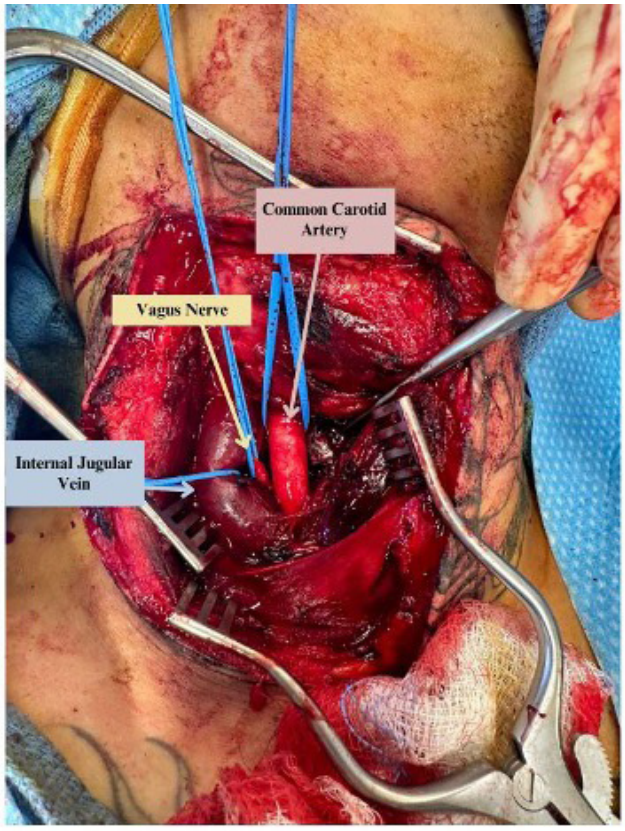

Figure 2 Operative dissection demonstrating isolation of the common carotid artery, vagus nerve, and internal jugular vein. Credit: Surabhi Reddy, MD.

in patients with PNI.[21] However, caution should be exercised when the airway is very bloody, as the camera can easily be obscured and will need to be cleaned before another attempt. If an airway cannot be established by the endotracheal route, a definitive airway can be established by cricothyroidotomy. In the hands of experienced providers, success rates of >80% have been reported, even in the context of severe PNI.[19]

Severe hemorrhage can prove to be extremely difficult for the prehospital provider to manage. Tourniquets cannot be applied, and direct pressure should be used cautiously to prevent devastating neurological complications. Dressing impregnated with hemostatic agents, such as QuickClot Combat Gauze and Celox-coated gauze is extremely effective and has no reported morbidity.[22] In settings where blood products and tranexamic acid are available, they should be administered expeditiously.[23] Innovative products such as the iTClamp (Innovative Trauma Care, San Antonio, Texas, USA) have been deployed successfully and are now being recommended by the US Tactical Combat-Casualty Care.[24 25] (figure 3) The iTClamp functions by sealing the wound and creating a temporary hematoma to control hemorrhage[25] (figure 3). McKee *et al* performed a randomized control trial comparing the iTClamp, direct pressure, and balloon tamponade in a cadaver study and found that the iTClamp had no difference compared with balloon tamponade for fluid loss and took less time to apply.[26] Additionally, both the iTClamp and balloon tamponade were more effective than manual pressure.[26]

Finally, c-spine immobilization with collar placement should be used judiciously, as the collar can easily hide worsening hemorrhage, subcutaneous emphysema, tracheal deviation, or loss of pulses. This is supported further by the fact that the incidence of

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Figure 3 Demonstration of the iTClamp. This novel device is a hemostatic clamp that contains needles that are inserted into the skin and then the skin edges are clamped closed to seal the wound and temporarily control hemorrhage by creating a hematoma. With permission from JLea.[25]

major spine injury occurs in only 7% of cases of PNI with other injuries and only in 1.5% of isolated PNI.[19] If there is a mechanism consistent with concern for spinal injury, continue with the use of collar placement. However, if there is minimal concern based on mechanism and patient presentation, it may be more prudent to not place the collar and not place them routinely in penetrating trauma in general.[27] Patients should expeditiously be transported to level 1 trauma centers, and clear communication should be established between the receiving emergency department and EMS providers.

Initial assessment and treatment

Based on the EMS report, the trauma team and resuscitation bay should be prepared accordingly, with intubation equipment, blood products, foley catheters, thoracotomy, and tube thoracostomy equipment with easy access to portable X-rays. Team roles should be defined early, and advanced trauma life support principles should be carefully observed in the initial assessment.

Airway management can proceed similarly as in the prehospital setting if intubation has not already occurred. Clinical signs of impending airway collapse, such as stridor, hoarseness, bubbling from the wound, worsening tracheal deviation, or subcutaneous emphysema should encourage early intubation, in addition to usual indications, such as Glasgow Coma Scale (GCS) score of <8. As in the prehospital setting, VL is the preferred route, although DL in the hands of a capable provider is also often adequate. Cricothyroidotomy is the preferred invasive airway in the event endotracheal tube (ETT) cannot placed. Another less conventional option for airway management is intubation via existing tracheal laceration. In the event of a patient presenting with an existing injury that extends into the trachea already, it is reasonable to place an ETT into the existing laceration as a temporizing measure until the patient can be stabilized, critical injuries otherwise controlled, and then taken for definitive airway repair. Extreme caution is needed due to the risk of worsening a false passage. End-tidal monitoring is mandatory.

All trauma centers should have easily accessible surgical airway equipment on hand if an ETT cannot be placed. The minimum equipment that should be available for an emergency surgical airway should include a scalpel, an ETT and suction.

A dedicated suction system for emergency airways is critical. With penetrating trauma due to copious secretions and bleeding, it is imperative to be able to clear the airway and obtain clear visualizing and establishing an airway in these critical injuries. Additional adjuncts that are helpful include bougies and cricoid hooks.

Additionally, a consideration should be forming a dedicated multidisciplinary team for difficult airways as seen in the dialogue around respiratory illness treatment quality improvement initiative from Mark *et al*.[28] They created response teams to better identify difficult airways, ensure equipment was ready and available, and quickly deploy staff to these situations.[28] Although not all hospitals have the capacity to have specialists, having a team of this nature can help ensure that everyone can operate at their best level with the resources they do have.

Blind intubation should never be attempted, regardless of the presumed urgency of obtaining the airway, and surgical airway should be done first. Emergency tracheostomy can be performed in cases where there is extensive damage to the cricoid cartilage or superior trachea. The emergency physician or trauma surgeon who is not comfortable with this procedure should have an attending otolaryngologist or other surgical subspecialist with extensive airway experience, available as not obtaining the airway on the first attempt may result in disastrous complications. Central line placement should not occur until the definitive airway is secured and all other options, such as large bore upper extremity peripheral access or intraosseus placement have been exhausted.

After airway, breathing and circulation have been established in a stable patient, the neck should be inspected to ascertain platysmal violation. Assessing for platysma violation is critical and should be done with thorough physical examination probing to assess the extent of the wound to ensure that they do or do not extend past the platysma. An example of a burn patient who presented with neck and face injuries of various depths is depicted in figure 4. These situations are critical for determining the appropriate depth of injury to ensure that serious injuries are not missed. Those without violations have only soft tissue

Figure 4 Example of a polytrauma burn patient with injuries to the head and neck of various depths, making injury examination of critical importance to not miss a diagnosis. Credit: Steven Satterly, MD.

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Box 1 Hard and soft signs of penetrating neck trauma

Signs of penetrating neck trauma
Soft signs
⇒ Hemoptysis.
⇒ Hematemesis.
⇒ Oropharyngeal blood.
⇒ Dyspnea.
⇒ Dysphonia.
⇒ Dysphagia.
⇒ Subcutaneous air.
⇒ Mediastinal air.
⇒ Chest tube air leak.
⇒ Non-expanding hematoma.
⇒ Focal neurological defects.
Hard signs
⇒ Expanding hematoma.
⇒ Severe active bleeding.
⇒ Shock not responding to fluids.
⇒ Deceased or absent radial pulse.
⇒ Vascular bruit or thrill.
⇒ Cerebral ischemia.
⇒ Airway obstruction.

injuries and can be discharged from the emergency department after washout and closure of the wound, provided they have no other injuries or wounds. In patients who cannot be well examined due to body habitus, other severe distracting injuries, or agitation, time should not be wasted attempting to establish a platysmal violation, and a CT angiography (CTA) of the neck should be expedited.

Hard and soft signs should be rapidly assessed (box 1). In the unstable patient where life-threatening exsanguination is occurring, a Foley catheter can be carefully introduced into the wound and the balloon expands to tamponade bleeding when transporting the patient to the operating room[21 29] (figure 5). Our goal for systolic blood pressure (SBP) is to maintain an SBP of approximately 90 mm Hg. Lower pressures risk the possibility of a worsening stroke in the event of head vessel damage, and high pressures can dislodge a hemostatic clot. With significant hemorrhage in penetrating trauma, it is key to obtain hemostasis rather than to continue to transfuse, as these proximal injuries will continue to bleed despite additional transfusion. Therefore, permissive hypotension is acceptable to gain control of the bleeding.

A hemostatic dressing can also be placed into the wound.[21] Any of the hard signs require expedient transfer to the operating room for mandatory exploration, with consultation with vascular surgery, neurosurgery, otolaryngology, or cardiothoracic surgery if the injury extends to regions outside of the comfort of the attending surgeon (figure 6).

DEFINITIVE MANAGEMENT

As previously mentioned, the classic zones of the neck are still used to delineate the anatomy. This scheme provided a framework for management decisions and ease of access to anatomic structures, such as mandatory exploration in zone II with platysmal violation or triple endoscopy and angiography in zone III injuries. However, this dogma is being increasingly challenged, particularly given the evidence that exterior wounds correlate poorly with the exact zone of injury.[22]

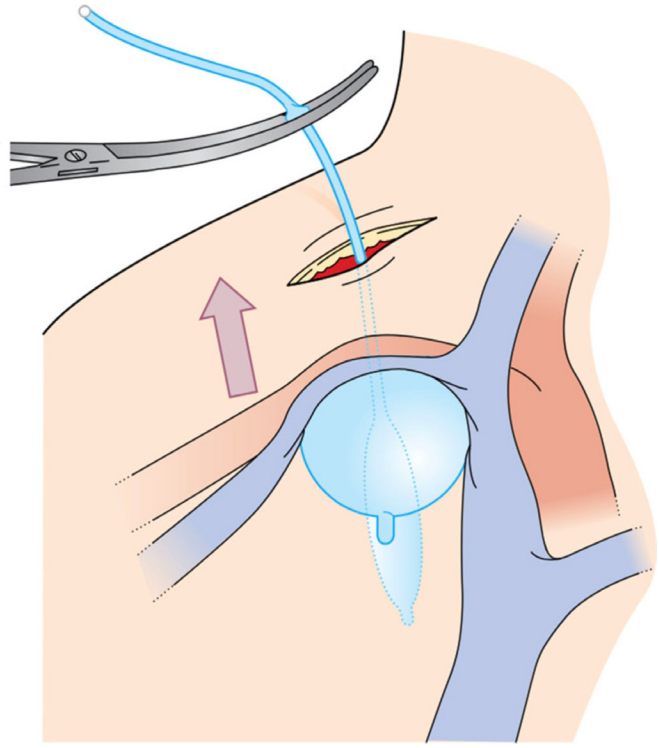

Figure 5 This diagram from Nowicki *et al* depicts the goal of using a Foley catheter to create a tamponade on a bleeding vessel through an injury. The Foley catheter is introduced into the wound, inflated, clamped, and slowly withdrawn in an attempt to occlude further bleeding.[29]

As the neck contains several complex structures in a compact space, such as numerous vessels, aerodigestive structures, and various neurological structures, all neck injuries, regardless of the caliber of the missile, should be approached with extreme caution (box 1). Vascular injuries, particularly arterial ones, can result in major hemorrhage, neurological deficits, or both, particularly when multiple vessels are involved. Common injury patterns include partial or total lacerations with or without obstruction, pseudoaneurysm formation, dissection, or fistula formation.[29] The incidence of vascular injury is as high as 25% and is most commonly carotid injuries, followed by vertebral artery injury.[2] Neck aerodigestive tract injuries, although less devastating than those that occur in the mediastinum, are a large source of morbidity and occur in up to 30% of patients with PNIs.[2] Non-vascular neurological injuries, such as injury to the brachial plexus, spinal cord and nerve roots, and cranial nerves, are also a significant source of morbidity.

Non-operative management and the 'no one' approach

Non-operative management has evolved as surgeons are becoming more aware of the non-zero risk of non-therapeutic interventions.[30] Prior to the evolvement of thin-sliced helical CTA, triple endoscopy with a traditional angiogram of the neck vessels was considered the gold standard for non-operative management. Triple endoscopy refers to performing laryngoscopy, bronchoscopy, as well as an endoscopy to fully assess for any injuries of the aerodigestive tract due to concern for missed injury with only one method.[31] However, there are risks associated with endoscopy, including perforation and hemorrhage and angiograms carry increased radiation-load risk, potential for contrast-induced renal injury as well as local cannulation site

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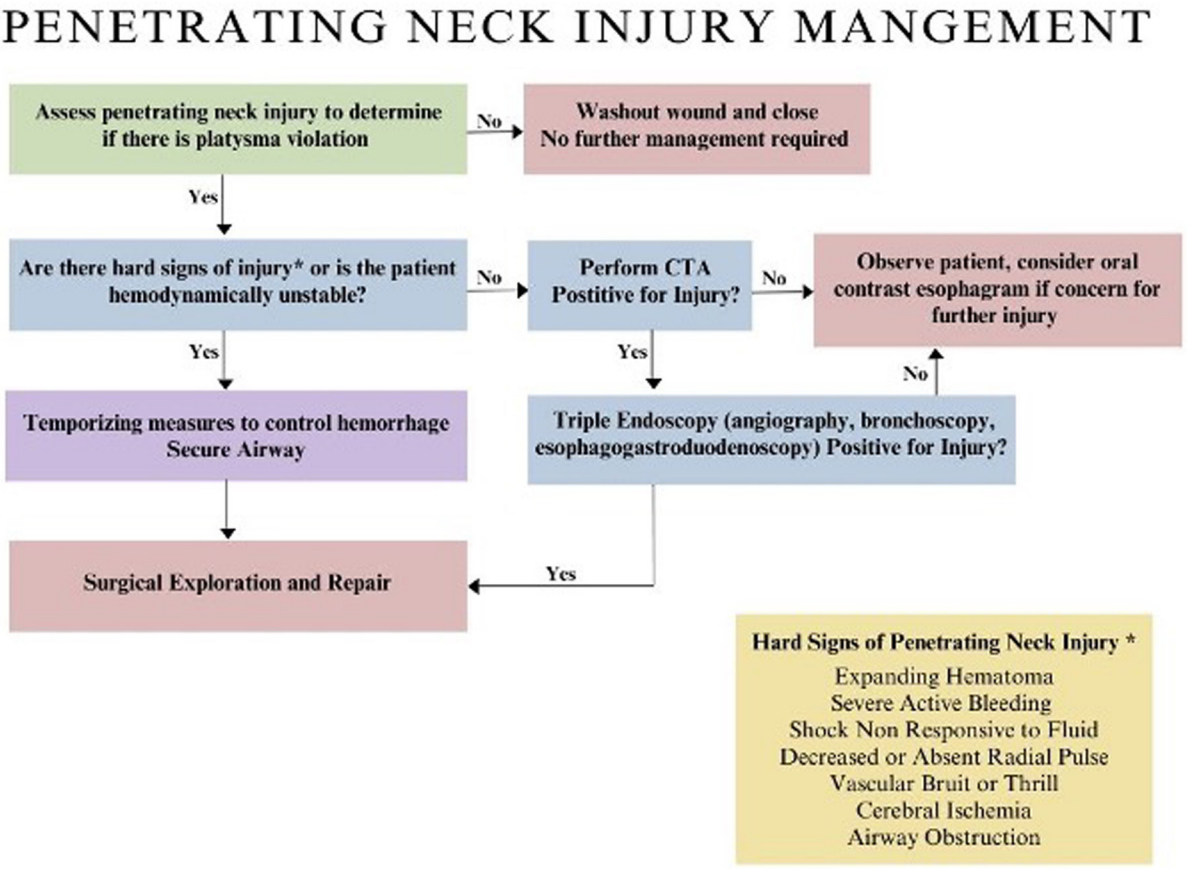

Figure 6 Management flowchart for workup of penetrating neck injury. Adapted from Nowicki *et al*[29] with permission. CTA, CT angiography.

complications. An example of the utilization of endoscopy to localize an esophageal injury is given in figure 7.

As the quality and availability of CT scan imaging continue to improve, 'no-zone' management for hemodynamically stable patients is rapidly becoming the standard of care in level 1 trauma centers across the USA.[30 32] Rather than divide the neck into three distinct regions, it is treated as a singular anatomic region, and the focus is placed on the nature of specific injuries.

Multidetector CTA of the neck and chest provides excellent resolution regarding vascular, airway, and aerodigestive tract injury. The American College of Radiology cites a 90%–100% sensitivity and 98.6%–100% specificity for evaluating vascular injury with CTA and cites a 100% sensitivity for aerodigestive injuries with 93.5%–97.5% specificity.[33] Patients can therefore be safely observed if no injury is detected. However, in patients with missile tracts near pharyngoesophageal structures, sensitivity is reduced to as low as 53%, and therefore confirmatory studies with contrast esophagram followed by esophagoscopy in cases of non-diagnostic studies are mandatory.[23 24] Finally, in cases of diagnostic uncertainty based on CTA, such as 'near-miss' injuries, further evaluation should occur with traditional angiography and triple endoscopy, or single modalities depending on the area of concern. If these options are not available, the surgeon must pursue a mandatory exploration, being careful to rule out contralateral injury.[34]

Operative management

The operative team should include an experienced anesthesiologist and consulting surgeons, and blood products should be made available. The operating room should be prepared with headlamps and an available gastroscope and bronchoscope. Fine

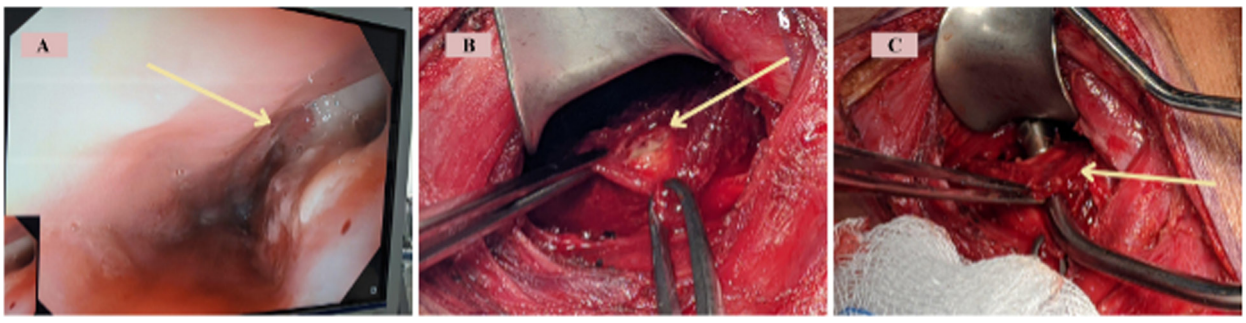

Figure 7 This series of images shows an injury discovered during endoscopy (A) which is highlighted by the arrow, followed by its localization for repair via an oblique incision (B) and (C) again with the injury highlighted with the arrow. Credit: Bracken Armstrong, MD.

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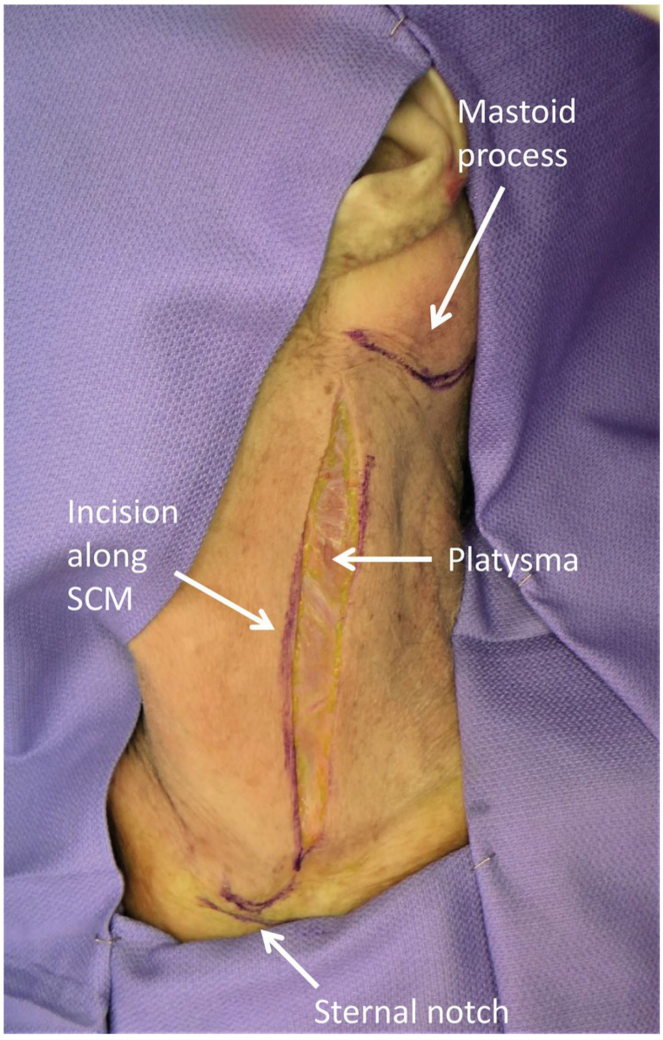

Figure 8 Example of an oblique neck incision.[35] SCM, sternocleidomastoid.

instrument trays should be opened, and patch grafts should be made available. It is often prudent to prep the bilateral thighs, in addition to the neck and chest, in case vascular reconstruction will need to be performed.

In stable patients who underwent CTA prior to arrival in the operating room, the choice of incision can be dictated by the presumed trajectory and concerning findings (online supplemental video 1). Most commonly, an oblique incision is made in the lateral neck medial to the sternocleidomastoid (figures 8 and 9).[35] The wound in which penetration or exit occurred should be avoided if possible. A collar incision should be considered in cases where a transcervical tract is suspected and to expose the bilateral neck (figures 10 and 11).[35] This should be performed approximately two finger breaths above the sternal notch. If needed, oblique incisions can be added for further exposure.

Finally, additionally, exposure may need to be obtained with a median sternotomy, which will be required for traditional zone I injuries. Example injuries include the proximal common carotid artery, innominate, vertebral arteries, and bilateral subclavian arteries. A clavicular head resection may need to be added for exposure of the left subclavian artery at its origin, given its posterior takeoff from the aortic arch.[36]

Repair of specific injuries will depend on the hemodynamic stability of the patient. Most low-velocity penetrating vascular

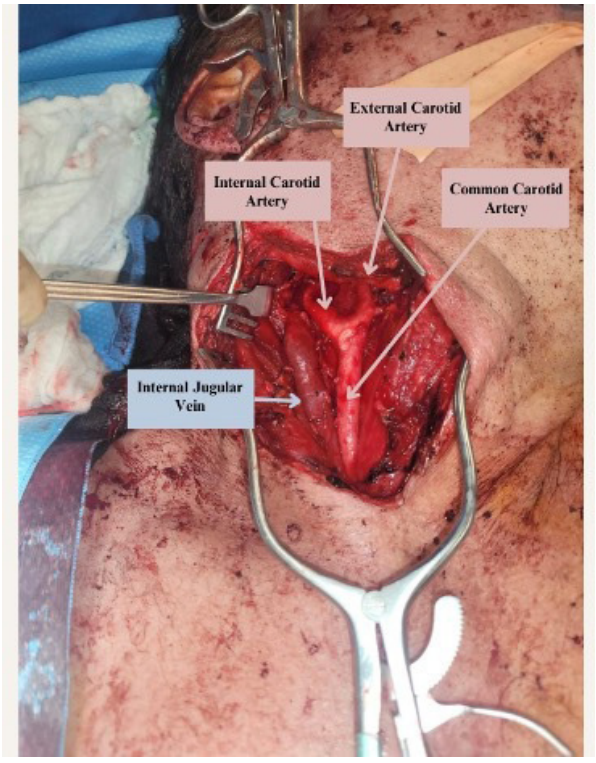

Figure 9 Example of an open oblique incision to expose the common carotid artery and internal jugular vein. Credit: Surabhi Reddy, MD.

injuries can be repaired primarily, and extensive blast injuries will require either ligation or reconstruction.[37] In hemodynamically unstable patients, one of the paired arteries can be safely ligated, given that there is adequate back bleeding. If there is concern for diminished perfusion through only one common carotid vessel, temporary shunting can be performed, with later reconstruction with a 6–8 mm expanded polytetrafluoroethylene

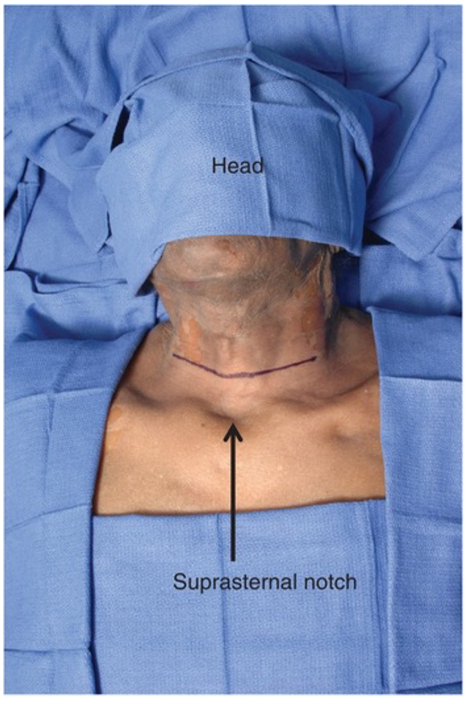

Figure 10 Example of a collar incision.[35]

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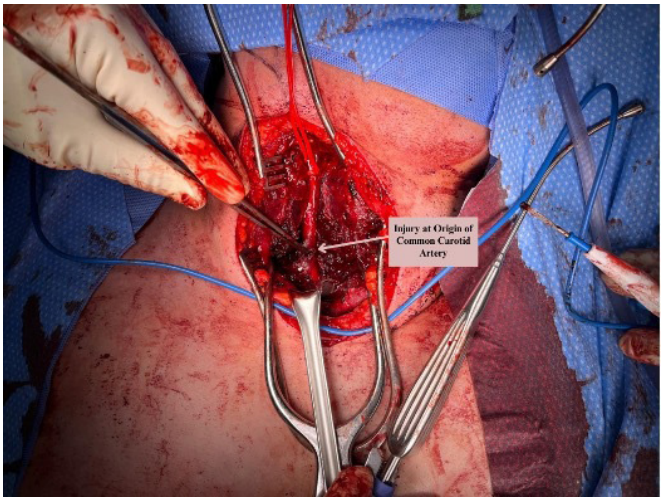

Figure 11 Example of operative exposure via a collar incision, which was used to expose an injury at the base of the common carotid artery. This injury was the result of a gunshot wound and required ligation. Credit: Graham Baluh, MD.

graft or reversed saphenous vein graft in cases where there is concern for contamination (online supplemental figure 1).[37]

Partial common carotid artery injuries <25% of the diameter of the vessel can be repaired with 5–0 Prolene suture after being debrided to healthy margins. More than 25% of injuries or segmental loss can be reanastomosed primarily if the loss is <1 cm. Otherwise, reconstruction is mandatory.

Internal carotid arteries should be repaired whenever possible; however, access can be very difficult, particularly near the skull base, and may need to be ligated or embolized by endovascular approaches.[38] Stroke rates are between 6% and 12% for carotid injuries, with internal carotid artery injuries having higher rates.[39] A study comparing repair to ligation found no difference in stroke rate; however, they did find that the ligation cohort presented with lower GCS scores.[39] This most recent study is a much lower rate of stroke with ligation, which had previously been reported to be 56%–100% in prior studies.[39] Lower-presenting GSW was also associated with a higher stroke rate overall.[39] External carotid arteries can be safely ligated, given high collateralization in the face.[40] A summary flowchart of operative management for PNIs is demonstrated in figure 12. An operative diagram from front-line surgery is also included for reference (figure 13).

Vertebral artery injuries can be very difficult to manage given their location.[36 41] V1 injuries, the traditional zone I injuries, will require median sternotomy with control of the vessel at its origin at the subclavian artery.[36] V2 injuries pose a particular challenge.[36] In the hemodynamically unstable patient or in cases where an endovascular approach is not possible, operative ligation can be performed by identifying the transverse process below the injury and ligating the vessel in the transverse foramina just medial to the TP with a permanent suture. V3/4 injuries, zone III injuries, are generally impossible to manage operatively; however, tamponade with bone wax or a similar substance can be attempted by placing it into the foramina inferior to the area of injury. Interventional radiology embolization will invariably be required.[36]

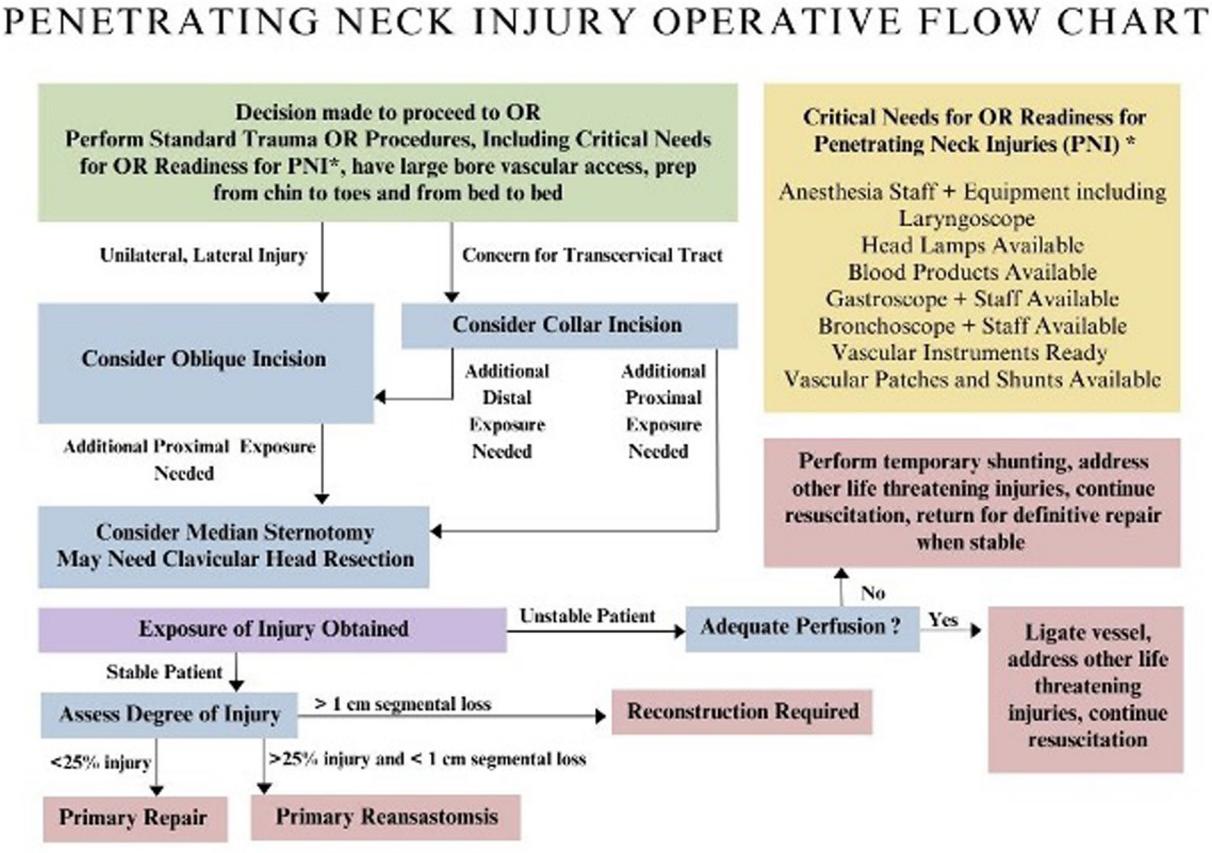
PENETRATING NECK INJURY OPERATIVE FLOW CHART
Decision made to proceed to OR
Perform Standard Trauma OR Procedures, Including Critical Needs for OR Readiness for PNI*, have large bore vascular access, prep from chin to toes and from bed to bed
Critical Needs for OR Readiness for Penetrating Neck Injuries (PNI) *
Anesthesia Staff + Equipment including Laryngoscope
Head Lamps Available
Blood Products Available
Gastroscope + Staff Available
Bronchoscope + Staff Available
Vascular Instruments Ready
Vascular Patches and Shunts Available
Unilateral, Lateral Injury
Concern for Transcervical Tract
Consider Oblique Incision
Consider Collar Incision
Additional Distal Exposure Needed
Additional Proximal Exposure Needed
Additional Proximal Exposure Needed
Consider Median Sternotomy
May Need Clavicular Head Resection
Perform temporary shunting, address other life threatening injuries, continue resuscitation, return for definitive repair when stable
No
Exposure of Injury Obtained
Unstable Patient
Adequate Perfusion ?
Yes
Ligate vessel, address other life threatening injuries, continue resuscitation
Stable Patient
Assess Degree of Injury
> 1 cm segmental loss
Reconstruction Required
<25% injury
>25% injury and < 1 cm segmental loss
Primary Repair
Primary Reansastomsis

Figure 12 A flowchart for basic operative management of penetrating neck injuries. OR, operating room.

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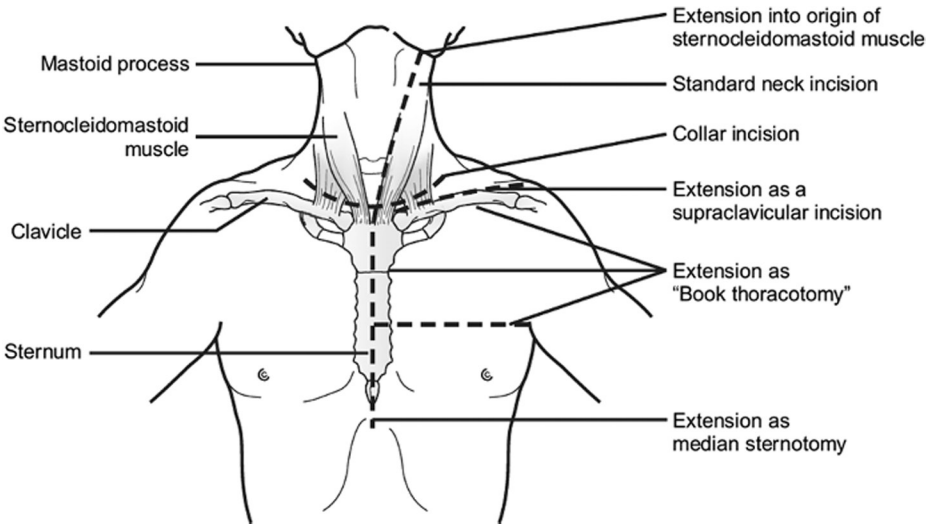

Figure 13 Diagram representation of various exposures for access to the structures of the neck. Credit: Matthew Eckert, MD.

Endovascular therapy is a newer field with increased use in the traumatic setting, generally reserved for stable patients. They can be very helpful for distal vertebral artery injuries or difficult-to-access locations.[37 42] However, they are generally contraindicated for carotid repairs due to the risk of thrombosis.[37] These attempts at minimally invasive intervention have been increasing; however, further study is needed prior to widespread acceptance for the management of zone II injuries.[42]

Venous injuries can generally be ligated if they are not bilateral, given the extensive network of collaterals.[43] In the setting of bilateral jugular vein injuries, either primary repair if <25% or patch or interposition repair if >25% of the diameter of the vessel should be attempted if the patient is hemodynamically stable.[44] In unstable cases, primary repair of a larger injury followed by revision when the patient is stable is an acceptable approach.[44]

Repair of the trachea can be very difficult for the unfamiliar trauma surgeon, and consultation of an attending otolaryngologist, or other qualified surgical subspecialist, should be made early if needed. Oblique lateral neck incisions or collar incisions are both usually adequate for access, and rarely a median sternotomy may be required for intrathoracic injuries.[36] Small injuries with minimal tissue loss can usually be repaired primarily with absorbable sutures after debridement to healthy margins.[36] In cases with >50% tissue loss, such as transcervical GSWs, resection of the segment and primarily anastomosis may be required.[45] We recommend a vascular muscular pedicle to buttress the repair and neck flexion be established with a guardian suture from the chin to the chest or head cradle.[46]

Esophageal injuries can usually be accessed through a left lateral oblique neck incision, although transcervical incisions are best accessed through a collar incision.[36] The surgeon should be sure to explore the esophagus circumferentially in cases where prior imaging was not obtained. This can be best performed with a collar incision or endoscopy if an oblique left lateral incision was used for a different purpose. Like tracheal injuries, clean small injuries can be repaired primarily with absorbable sutures after debridement, whereas >50% of injuries will require segmental resection, anastomosis, and pediculated flaps for protection, although with wide drainage.[47]

Prognosis/outcomes

Due to the amount of critical structures in the neck, there are a wide variety of devastating injuries that can occur that may leave patients with lifelong disability, such as injury to the brachial plexus, dysphagia, vocal cord paralysis, and airway injury requiring tracheostomy.[48–50]

Overall, the mortality associated with a PNI is 3%–6% accounting for approximately 3500 deaths yearly.[17 48] Half of these deaths occur due to hemorrhage from vascular injuries, and 10% of PNIs have been reported to have carotid artery injuries.[17 48 51] Of those with vascular injury, 40% will develop complications.[17] Of those with aerodigestive injuries, the mortality rate is 11%–17%.[17] Aerodigestive injuries occur in 23%–30% of injuries.[17 48]

Given their relatively high prevalence of traumatic injuries and mortality rate, we need to continue to improve our management strategies of PNIs with particular emphasis on hemorrhage control.

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